ULLETIN No. 31

LIDGERWOOD CABLEWAYS

LOCKS AND DAMS

LIDGERWOOD
MANUFACTURING CO
NEW YORK

WORKS OF THE LIDGERWOOD MANUFACTURING COMPANY

Main Works

Dikeman, Coffey, Ferris and Wolcott Streets

BROOKLYN, N. Y.

Foundry Department

Frelinghuysen Avenue

NEWARK, N. J.

Foundry, 120 x 550 Feet Pattern Shop, 40 x 340 Feet

LIDGERWOOD CABLEWAYS

FOR HOISTING AND CONVEYING

THIS SECTION OF THE CABLEWAY CATALOG SHOWS TYPICAL INSTALLATIONS OF LIDGERWOOD CABLEWAYS FOR BUILDING DAMS AND LOCKS—OTHER SECTIONS SHOW THEIR USE FOR BRIDGES, CANALS, CHANNELS, DRY DOCK AND POWER HOUSE WORK; FORTIFICATIONS; FILTRATION SYSTEMS AND GENERAL CONCRETE CONSTRUCTION; DITCH AND SEWER WORK; CUT, TUNNEL, MINE AND QUARRY WORK, AND OTHER INTERESTING INDUSTRIAL PURPOSES SUCH AS HANDLING CARGO, ASH AND FUEL, GATHERING AND HANDLING LOGS FOR LUMBER AND PULP-MAKING

1912

LIDGERWOOD MANUFACTURING COMPANY

GENERAL OFFICES
96 LIBERTY STREET, NEW YORK, U. S. A.

WORKS
BROOKLYN, N. Y. NEWARK, N. J.

BRANCH OFFICES
CHICAGO, SAN FRANCISCO, SEATTLE, BOSTON
PHILADELPHIA, PITTSBURGH, CLEVELAND

EUROPEAN OFFICE
CAXTON HOUSE, WESTMINSTER
LONDON, S. W., ENGLAND

Lidgerwood Reputation

The enviable reputation of Lidgerwood Cableways is a result of the care with which each is designed and constructed. Competent engineers, long trained in the designing of cableways, are employed. Improvements are made from time to time as experience indicates with the result that the most efficient apparatus is obtained.

Cableway Engineering

Every cableway installation, to be successful, should be considered as an engineering proposition. Its location, the character of the duty to be performed, its relationship to the series of operations to be performed, and its required capacity all demand that it be considered in all its details by competent engineers. A modification of the span means a modification of the hoist and the carrier system. A modification of the towers may require modification also of the hoist. Changes in load capacity involve careful consideration of the hoist, the carriage, carriers, hoisting purchase, and many other details. Perfection in detail is as essential to success as a good general design.

Efficiency

Cableways employed in many kinds of modern engineering work are only links in the chain of mechanism and labor. Temporary shut-downs for minor repairs become the source of losses which may represent large sums in the aggregate. While the cableway is shut down all the other elements of expense continue.

Twenty years of development with the gradual elimination of weak elements has produced a cableway of high efficiency. Our most recent improvements in Lidgerwood Cableways have reduced these losses to a minimum. The eight cableways, placing concrete in the Gatun Locks at Panama, lost only one per cent. in time for shut-downs for repairs of every kind during the whole of their first year of service. Such results are possible only with careful management and care of the cableways in service.

Development of Cableways and Fall Rope Carriers

The efficiency of a cableway depends largely upon the Fall Rope Carrier System. The first three cableways built by the Lidgerwood Manufacturing Company, twenty-three years ago, had chain-connected fall rope carriers. Repair bills were large, the time lost was appalling and the irritation to the buyers so great that the Company made no further attempt to sell cableways until three years later when the invention of the Button Stop Fall Rope Carrier System made success possible. This style of fall rope carrier was first employed in a cableway to handle iron ore at Thomas A. Edison's Iron Concentrating Plant in New Jersey. The history of successful cableways began with that installation. The early type of Button Stop Fall Rope Carrier was crude and faulty but with all its faults had many advantages over the chain-connected carriers. Its weight was only one-tenth. There were no chains to tangle and no rollers to wear out. The carriers were conveyed on a horn of the carriage free from the main cable, upon which they only rested when not in motion.

Twenty Lidgerwood Cableways were used on the Chicago Drainage Canal. The repair costs were large. Constant attention devoted to strengthening the button fastenings and slots in the heads of the carriers showed the inherent fault in the design. Impact is in proportion to weight. Additions of metal were offset by increased impact. With carriage speeds of 800 feet per minute the repair costs and loss of time from breakages were serious. The chief faults were in the buttons and fall rope carriers. After it was demonstrated that higher speeds than 800 feet per minute were not to be expected from our old form of slotted head carriers we determined to try out new forms at the Lidgerwood Testing Plant. The best form produced of slotted head carrier was wrecked inside of a dozen trips at a carriage speed of 1200 feet per minute. Adding material to the carrier heads added to the impact at an equal ratio and no advantage was gained. A new type of button and carrier head was needed. These have been produced. Lidgerwood Cableways are now in operation with carriage speeds of 1800 feet per minute with a minimum of repair costs and time losses. See Figs. 1, 2, 3 and 4 on following pages.

Control

An important point considered in the design of Lidgerwood Cableways is the ease of operation and control. Economy and safety both depend upon the operator being able to see what his cableway is doing and watch it in operation and upon his ability to operate it at high speed all through the ordinary hours of a working day without fatigue.

In our Panama Cableways, the methods of control were so carefully designed that none of the operators have ever complained of the labor, although their cableways were operated 12 hours a day and within the tropics.

Cableway Testing Station

The Lidgerwood Manufacturing Company at its Newark Works maintains a Cahleway Testing Station of 600 feet span where new devices are tested before adoption and new problems in cableway practice may be worked out under the superintendence of its Cableway Engineers. Three months experimenting at this Station was devoted to developing the carriage and fall rope carrier which forms so important a feature in the present style of Lidgerwood Cableways.

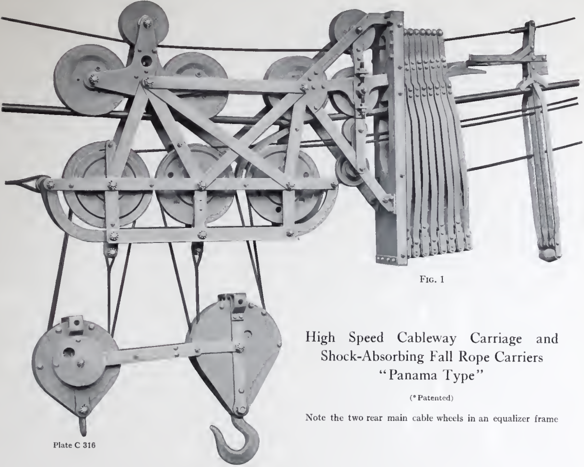


Fig. 1

High Speed Cableway Carriage and Shock-Absorbing Fall Rope Carriers "Panama Type"

(* Patented)

Note the two rear main cable wheels in an equalizer frame

Plate C 316

High Speed Cableways—"Panama Type"

When the Lidgerwood Manufacturing Company was awarded the contract for thirteen cableways for Panama they were the highest bidders in dollars and cents, but their guarantee of capacity was relatively higher than their price. Their bid was accepted by the Isthmian Canal Commission because it offered the greatest values. The capacity guaranteed demanded a carriage speed of 1800 feet per minute. The cableways have more than made good their guarantee. While every portion of the cableway from the hoist to the fall blocks received careful attention in this most recent development, the special features which keep the present type of Lidgerwood Cableways beyond competition in speed and efficiency are the Shock-Absorbing Fall Rope Carriers, Taper-Pin Buttons and Pivoted Carriage.

Pivoted Equalizing Carriage

The carriage has three main cable wheels besides the wheel supporting the carrier horn. The two rear wheels are placed in an equalizer frame. In this way the weight is equally distributed upon the wheels. This makes for efficiency in operation and prolongs the life of the main cable and of the cable wheels.

To insure that the carrier horn shall always enter the opening of the carriers in the same position in picking up the carriers it was necessary to keep the horn at all times in the same correlation with the main cable. The horn is, therefore, self-adjusting. It is pivoted to the carriage and the horn frame rides on a wheel on the main cable.

* February 14, 1911.

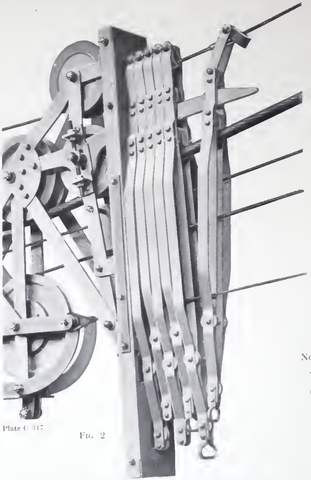


Plate C 317 Fig. 2

Button-Picking Fall Rope Carrier Off Carriage, Showing the Action of the Shock-Absorbing Carrier Head

Note the Swinging Eye!

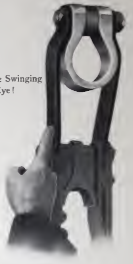


Plate C 318 Fig. 3

Swinging Eye at Head of Carrier

Note the Double-Jointed, Shock-Absorbing Carrier Top!

Plate C 319 Fig. 4

The Shock-Absorbing Fall Rope Carrier

Shock-Absorbing Fall Rope Carriers

(*Patented)

Nothing that the Lidgerwood Manufacturing Company has ever produced has meant more for efficiency than this type of fall rope carrier. Instead of a slotted head, receiving a wedging impact against the button at two points only, the button collides with an eye or ring. The impact is distributed equally around the face of the eye. The eye does not weigh one-tenth as much as the slotted head and if subjected to the same strains would withstand harder service. The eye is hinged and the head of the carrier is also hinged below. The shock-absorbing action of this construction is so great that carriers of this style have been experimentally operated for hours at a time without damage at speeds up to 3000 feet per minute.

Slow Speed Carriers

(*Patented)

By slow speed is meant any speed below 1000 feet per minute. We have perfected a new type of carrier which retains most of the features of the high speed carrier without its shock-absorbing features. It is recommended for cableways which are not required for long service and where economy in first cost is an important consideration.

* February 14, 1911.

Plate C 312

Fig. 5

Plate C 311

Fig. 6

The button that "holds" without injuring the rope and picks off fall rope carriers moving 1800 feet per minute.

The Buttons

(* Patented)

The buttons are practically in one piece. They are taper-bored. A tapered pin of soft steel is inserted in the rope forming a tapered portion of the rope. The button encloses this. A thimble is slipped into the open end of the button and held in place by a small spreader in the rope.

The surfaces of the rope and button, in contact over which the impact of the carrier are spread, measure nearly 12 square inches or sixteen times as much as in the older form of button. The wires are effectually protected from injury. The button is unbreakable. Buttons receiving blows for months from carriers traveling 3000 feet per minute slipped but one-quarter inch. Special jack-screws were required to remove the buttons.

Results at Panama

The eight cableways at Panama laying concrete in the locks, operated twelve hours per day, lost but one per cent. of time in shut-downs for all repairs from all causes. Probably one-half of this was caused by the fall rope carriers This means seven and one-third minutes per day. Comparing this with the delays on the Chicago Drainage Canal which averaged about forty-five minutes per day, working ten hours, or seven and one-half per cent., equal to nearly fifty-four minutes in a twelve-hour day.

Varieties of Cableways

Cableways of many varieties are built. Some have fixed towers, either of a permanent character, or with easily-moved "A" frames. Some have one fixed tower and the other supported on a float in water or traveling on rails radially about the fixed tower. Others have both towers traveling on tracks laid parallel to each other.

Lidgerwood Cableways are built to be operated by steam, compressed air or electricity. Electrically-operated cableways may be provided with remote control as simple as that used for controlling electric trains operated from any convenient point.

Lidgerwood Cableways have been built with spans up to 2200 feet carrying 10-ton loads and shorter ones to carry loads of 50 tons.

* May 28, 1907, and August 22, 1911.

Panama Canal Locks

General View of Upper Locks and Forebay, Looking North

[illegible]

The building of the Gatun Locks was begun on August 24, 1909, when the handling and mixing plants were set in motion and the first concrete was laid. There are six locks in three pairs at Gatun, making the lift from sea level to 85 feet [illegible]. Each lock will be 110 feet wide, having a usable length of 1000 feet and there will be 40½ feet of water over the sills when the surface of Gatun Lake is at its height above mean sea level. The concrete construction, including the locks and approach walls, is estimated at about 2,000,000 cubic yards. The method of handling the materials for concrete involves three distinct operations, the first being the assembling of material. About 2,250,000 barrels of cement will be required for the concrete at Gatun. This cement is unloaded from barges at the cement warehouse at Gatun by electric cranes. The barges come up the old French Canal from Colon. The rock is quarried from Porto Bello, about 17 miles from Colon, and is towed in barges up the old French Canal to Gatun where it is unloaded by two duplex Lidgerwood Unloading Cableways. Sand is also received in barges and unloaded by a single Lidgerwood Cableway. The rock and sand being delivered to storage piles. An electric railway runs underneath the cement warehouse and under the rock and sand storage piles, thence up to the battery of concrete mixers. Cars pass along this railway and are charged automatically with cement, sand and rock in the proportions of 1, 3 and 6, thus completing the operation of assembling the materials. The loaded cars run up an incline to a platform over the mixers where the material is dumped; after mixing it is dumped by gravity into tip buckets. These buckets are carried on cars that run on a railway track along the west bank of the lock site. After the concrete is dumped into a car an electric locomotive, operating on the third rail system, takes it to a point along the lock site.

Panama Canal Locks

Plate (32)

Upper Gatun Lock Looking South from East Wall, March, 1910

Eight Lidgerwood High-Speed Cableways

The loaded buckets, 68 cubic feet capacity, are taken from the cars by the cableway and lowered into the chamber at any spot desired.

Four duplex cableways span the lock site a width of 800 feet. A single strand of any pair of duplex cableways is capable of handling a load of six tons and in addition to depositing concrete the cableways are used for handling forms and placing fixed irons for masonry. The duplex cableway towers are each 85 feet high, of steel construction, and mounted on heavy trucks running on a double trackway of 90-pound rails.

Each of the tail towers which are on the east bank of the lock site, moves synchronously with the towers opposite on the west bank, and the movement of each is controlled from the control station in the towers.

The carrying cable is a patent locked steel cable, $2\frac{1}{4}$ inch diameter and on this cable a traveler or carriage is moved back and forward over the lock chamber. The maximum distance the carriage is required to run is 670 feet, the greatest lift is 175 feet. The machinery for operating is mounted in the head towers on the west bank of the lock site. It consists of the main hoist for actuating the hoisting and conveying ropes, a separate hoist for operating the automatic dump and a third hoist for propelling the tower. The tail towers also each carry a propelling winch with local control. The eight high-speed cableways at the Gatun Locks used for laying concrete were operated 12 hours per day and lost but one per cent of time for all repairs and shut-downs for all causes. Hence these cableways were credited with an *efficiency of 99 per cent.*

Panama Canal Locks

Head Towers of Cableways for Lock Construction, with Electric Trains for Delivering Concrete. Gatun Locks

The [illegible] cableway towers travel the whole length of the flight of locks about 3000 feet. There are eight cableways [illegible] arranged in four pairs of traveling duplex towers. All the towers are readily moved along the tracks by [illegible] electric winches. The towers are provided with brake apparatus and locking clamps, in addition to the [illegible] brakes on the propelling winches. This is necessary on account of the grade of trackway which is 2.1 per cent for a large part of its length.

Diagram Showing Location of Cableway, Mixers, Etc.

Panama Canal Locks

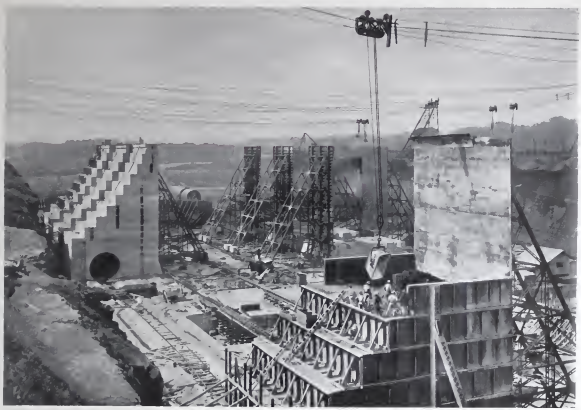


Plate C 324

Constructing Side Wall Monoliths, Upper Lock Gatun, February, 1910

Eight Lidgerwood High-Speed Cableways

Some Records

About 2900 cubic yards of concrete have been placed in the locks in one day of twelve hours by the battery of eight (four duplex) lock cableways in addition to handling forms and ironwork for the day's work. Three duplex cableways have placed 2700 cubic yards in 10 hours. One duplex cableway has placed 64 cubic yards in 32 minutes. Thirty complete round trips have been made in one hour with one cableway.

The cableways, so far as delays from breakage or repairs were concerned, while working 12 hours per day, have been kept up to an *efficiency of 99 per cent.*

Plate C 325

Hooking on the Tubs of Concrete

Panama Canal Locks

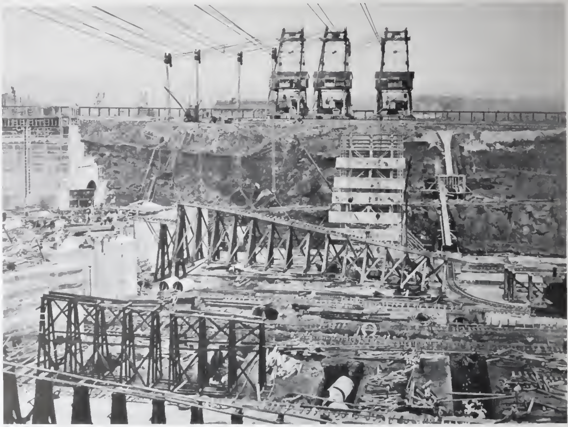


Photo C 326

The Lock Cableways "En Bloc" Being Used for Moving a Timber Trestle

Cost of Concrete in the Gatun Locks at Panama from the "Canal Record," Nov. 8, 1911

Masonry	July	Aug.	Sept.	Total
Concrete—Quantities—cubic yards	64,199	59,332	51,650	175,181
Cement	$1 5563	$1 5729	$1 5648	$1 5644
Stone	1 9915	2 2000	2 1484	2 1084
Sand	8365	9811	9461	9178
Mixing	1335	1446	1541	1433
Total cost	$4 5178	$4 8986	$4 8134	$4 7339
Large Rock—Quantities—cubic yards.	5,370	4,416	1,634	11,420
Cost	$0 7806	$1 2564	$1 1203	$1 0132
Masonry—Quantities—cubic yards	69,569	63,748	53,284	186,601
Concrete	$4 1690	$4 5593	$4 6658	$4 4442
Large rock	0603	0870	0344	0620
Wood forms	4265	4774	3698	4277
Steel forms	1302	1287	1506	1355
Placing	3240	3632	3725	3513
Reinforcements	0083	.0244	0157	0158
Pumps	0719	0968	0831	0836
Power	0425	0473	0751	0535
Coffer dams				
Maintenance of equipment	2001	1771	1637	1818
Plant arbitrary	7110	1 0644	8800	8800
Division expense	0821	1033	0874	0909
Total division cost	$6 2259	$7 1289	$6 8981	$6 7263
Admin. and general expense	1983	2270	1967	2076
Total cost	$6 4242	$7 3559	$7 0948	$6 9339

Cost of Concrete

The cost of stone, sand and cement at Gatun, due to local conditions and distant source of supply for the first two items, is rather excessive and exceeds the total cost per cubic yard for similar material at Miraflores or Pedro Miguel Locks by about $1.67, according to the "Canal Record." This difference for which the concrete-making and placing plant at Gatun is not responsible when deducted from the total cost of concrete per cubic yard at Gatun as given appears to show a difference in favor of the Gatun work.

Panama Canal Locks

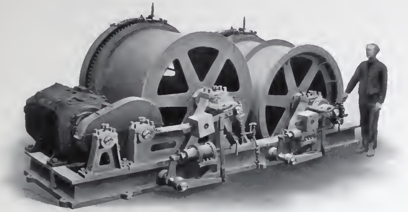


Plate C 327

The Lidgerwood High-Speed Electric Cableway Hoist

The lock-building cableway hoists were designed for speed and ease of control. The motor is General Electric Company, interpolated pole series railway type, 150 horse power, for 550-volt direct-current circuit, with current limit automatic and hand control whereby the operator may cause the motors to be accelerated by throwing the master-controller handle to full on position, the motors taking a predetermined current from the line. Or, he may accelerate the motors at any rate he desires slower than that determined by the setting of the current relay. He may slow up his motors by a retrograde movement of the controller handle thus cutting resistance back into the motor circuit. The control panel carries an overload relay which throws the motor off the line in case of overload by causing the line contactors to drop out. Before the motor can again be thrown on the line it is necessary for the operator to bring the master-controller handle to the off position, after which the motors are started in the usual manner. These features make this control ideal for high speed work. The brakes are electrically-operated air brakes, as well as friction clutches, a separate electrically-driven air compressor being employed. The control arrangement both for the air brakes and friction clutches is designed for operation locally or at a remote point.

The hoist has cast steel gearing with machine-cut teeth throughout. The diameter of the hoisting and conveying drums is 54 inches and the hoist is geared to give a hoisting load speed of 333 feet per minute. The conveying speed is 1800–2000 feet per minute. This conveying speed is permissible with our new Panama Type Button and Shock-Absorbing Fall Rope Carrier.

Plate C 328

The Operator

Cataract Dam, Australia

Plate C 77

Two Lidgerwood Cableways on Cataract Dam

New South Wales Government, Sydney, N. S. W.

Span, 1100 feet   Load, 4½ tons

Two electrically-operated cableways, spans 1100 feet, load handled 4½ tons, one arranged with 57-foot traveling towers, and the other with 57-foot stationary towers, were furnished by us for the construction of a large masonry dam for the water supply of the City of Sydney, which was completed in the latter part of 1907. The order was placed after a very thorough investigation of American methods of dam construction. Several Lidgerwood Stiff Leg Derricks were also furnished.

Mr. L. A. B. Wade, C. E., of the Public Works Department of Sydney, has expressed himself as highly pleased with this plant, both for purposes of excavation and construction of the masonry. Mr. Wade was responsible for the design and construction of the dam. The resident engineer at the dam was Mr. J. Symonds, C. E.

The water supply of the City of Sydney is derived from the Nepean and Cataract Rivers, which have a very extensive watershed, but it became necessary to conserve their flood waters by the construction of a dam which will impound about 25,700,000,000 gallons in a reservoir with a surface area of some 2145 acres. The dam is straight on top, about 850 feet long, with a height of about 154 feet above the river bed, and the foundations go about 40 feet below into solid sandstone. The full supply level of the water surface is about 7 feet below the crest. The flood waters are taken over a spillway at one side, which has a length of 730 feet.

Cataract Dam, Australia

Plate C 82

Cableway Head Towers

One Traveling and One Stationary Tower

The Special Lidgerwood Electric Hoists, illustrated on next page, were each operated by two G. E. 57-direct-current motors designed for 500 volts and series parallel controller, and were equipped with double 53-inch diameter friction drums, as shown in the accompanying illustration. These hoists were arranged for high speed in handling light loads. Materials of construction were lowered to a great depth in the early part of the work, and it was, therefore, necessary to hoist the empty skip at a very high speed. The full load of 4½ tons was, however, hoisted at a speed of 200 feet per minute and conveyed along the cable at 1000 feet per minute.

Barren Jack Dam, Australia

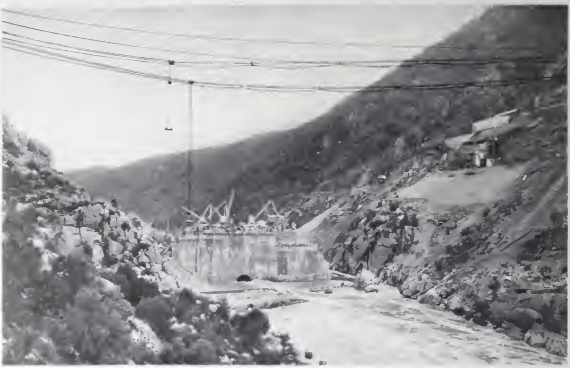


Plate C 329

Barren Jack Dam--New South Wales Government

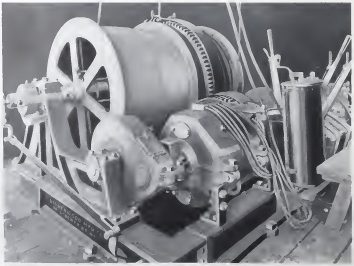


Plate C 81 Copyright, 1904, by Lidgerwood Mfg. Co., New York

The Electric Cableway Hoist

For Cataract and Barren Jack Dams, New South Wales Government

Two Lidgerwood 1200-foot span traveling cableways were used on this work, both being electrically operated and designed for handling 8 to 15 tons. The plants in general are similar to those employed on the Cataract Dam.

The Barren Jack Dam forms part of the Murrumbidgee River irrigation scheme, New South Wales. The length of the dam, on the crest, is about 784 feet with a curve of 1200 feet radius and maximum height of 240 feet. The structure is of cyclopean concrete. The base of the dam is 163 feet wide. The maximum depth of water behind the dam is 224 feet and the capacity will amount to 33,380,000,000 cubic feet. The catchment area embraces 5000 square miles. The dam is located on an extraordinary favorable site and on account of the proximity of the suitable materials for construction it will cost $4.86 per acre foot of water stored which is one of the lowest costs on record. The dam is located about 36 miles from the new capital city of Australia.

Wachusett Dam

Plate C 75

Two Lidgerwood Traveling Cableways—Building Wachusett Dam

MacArthur Brothers Company, Chicago, Ill., and Winston & Company & Locher, Contractors

Span, 1253 Feet; Load, 5 to 10 Tons; Aerial Dump

The Wachusett Dam, across the Nashua River at Clinton, Mass., for the Metropolitan Water Works, forms an immense reservoir, capacity 65,000,000,000 gallons, for the water supply of the Boston Metropolitan District.

The main dam is about 900 feet long between the terminal structures, the maximum height 228 feet. The bottom width of the dam is about 175 feet. The dam is constructed of rubble masonry, carried deep into solid rock formation at the bottom and sides of the valley, consisting of large granite blocks laid in cement mortar with the exception of the exposed faces which are of rock-faced granite ashlar in ranged courses, well bonded to the rubble by frequent headers. Total amount of masonry 275,000 cubic yards.

The rock was quarried and loaded by derricks directly into cableway skips on flat cars at the State Quarry, about two miles away from the dam, and brought by train under the lines of the cables, which picked the skips up and delivered them to the masonry laying derricks.

The cableways enabled large single stones, frequently ten tons in weight, to be readily taken from the cars and set directly in the masonry.

All of the excavation was removed by the cableways. The use of the Aerial Dump was of great value. After sufficient masonry had been placed in position to bring the dam up to a height to permit back filling behind as well as in front of the dam, material was hoisted direct from excavation with a skip on one cableway, the skip transferred to the other cableway and dumped with the Aerial Dump directly into the back fill, making one handling of the material from the excavation to the fill. The cableway hoisting from the excavation was placed directly over the line of work, while the second plant was moved up or down stream as required, and directly over the embankment to be made. A great deal of this work was carried on at night, and the laying of masonry during the day shift.

New Croton Dam

Plate C 95

Copyright, 1896 by Lidgerwood Mfg. Co., New York

One of Three Cableways

At the New Croton Dam, Croton-on-Hudson, N. Y. — Early Stage of Work

Span, about 1200 feet; Load, 10 Tons

Three cableways were used in handling and setting the masonry, also for hoisting and dumping excavated material from the foundations for this world-famous dam.

All operations were governed by electric bell signals given from the work to the engineman.

Plate C 96

Copyright, 1906, by Lidgerwood Mfg. Co., New York

Face of Completed Dam

New Croton Falls Dam

Plate C 330

Main Dam for Croton Falls Reservoir

For New York City Water Supply

Span, 1434 Feet; Load, 10 Tons

Two ten-ton Lidgerwood Traveling Cableways, steam operated, were employed for the main dam; span of each being 1434 feet. Head towers 93 feet high and tail towers 103 feet high. The engines had double $12\frac{1}{4}$ x 15 cylinders; drums 59 inches diameter.

The main dam is constructed entirely of concrete and cyclopean masonry, the concrete being in the proportion of 1:3:6, with about 33 per cent. of large stone and 67 per cent. of concrete. Height of dam from rock foundation to the top is 173 feet. The dam on the crest line is 1100 feet long.

The quantity of earth excavated in the main dam was 280,000 cubic yards and of rock 95,000 cubic yards.

The material of which the dam is constructed was handled by two of the Lidgerwood Cableways and two lines of guy and stiff leg derricks, one on either side of the excavation. The guy derricks were located about 175 feet apart and the stiff leg derricks 104 feet apart.

The guy derricks were used until the guys interfered with the operation of the cableways so that they were replaced by stiff leg derricks.

The cableways delivered the concrete in $2\frac{1}{2}$ cubic yard buckets.

The material handled in the construction of the dam by the cableways and derricks was:

24,500 cubic yards of cyclopean masonry.
30,000 cubic yards of concrete facing blocks.
15,000 cubic yards of concrete masonry.
545 cubic yards dimension stone.
230,000 bbls. cement.
575 tons of reinforcing steel.
180,000 cubic yards of refilling.

Cyclopean masonry used in the dam contained stone of one to three cubic yards each. The stone was quarried from a point of hill, three-fourths mile up-stream.

Plate C 331

Head Traveling Towers
93 Feet High

Cross River Dam

Three Traveling Cableways—Down Stream Face, Cross River Dam

Span 1250 Feet. Load 5 to 10 Tons. Aerial Dump. 93 foot Head Towers, 63 foot Tail Towers

The Cross River Dam, recently completed, impounds a reservoir of 10,000,000,000 gallons capacity on an easterly tributary of Croton River. The waters thereby stored are discharged directly into Croton Lake, the main reservoir for the City of New York.

The main dam crest is 900 feet long, height 170 feet, the foundation being carried 40 feet below the river bed, maximum bottom width about 115 feet. The construction is cyclopean masonry, faced with large cast concrete blocks, requiring 160,000 cubic yards of masonry, which includes about 18,000 cubic yards of facing blocks. The south end of the main dam, near the head towers of the cableways, terminates in a short earth dam with concrete core deflected upstream. The north end of the dam terminates in a circular bastion 30 feet in diameter, containing a [illegible] chamber for flash boards. Beyond the bastion the structure is continued east by a reinforced monolithic concrete waste weir, its crest about 240 feet long and 10 feet below the top of the dam. The main quarry is shown at the left of the cut.

Irregular pieces of gneiss up to four yards, laid in 1–3.2–5.8 concrete, constitute the main mass, with facing blocks of 1–2½–4½ Portland cement concrete, built in 30-inch courses, one course in advance of balance of masonry.

Cross River Dam

Plate C 72

Early View—Derricks on Trestles

The three traveling cableways were seated upon the same tracks to cover the entire area of the work, as well as the concrete and crushing plants, railroad tracks, blacksmith, machine and wood-working shops, and storage yard. Two cableways were used for building the dam, the third for feeding the crushers and bringing stone from a quarry on the north side of the valley. All three used on excavation.

One No. 9 and two No. 5 crushers, with elevators, screens and bins, were combined in one structure, with two 5-foot cube mixers for the dam and one 4-foot cube mixer for making concrete blocks. The cableways, derricks, etc., were operated from a central air plant of 1120 H. P. Two stationary Lidgerwood Cableways of about 800-foot span were also used on the early excavation in the bottom of the valley. It is interesting to note that this very extensive plant represented over 25 per cent. of the entire value of the contract.

The concrete blocks, maximum weight six tons, were made by a method designed and patented by Mr. J. O. Winston.

Records

The entire masonry was built in a little over ten working months. Two cableways handled in the month of October, 1906, 18,500 cubic yards of masonry, of which 1600, cubic yards were concrete blocks. With six gangs at work on the dam, each composed of two masons, six laborers, and a derrick engineer, this record represents 108 cubic yards per ten hours for each gang, in addition to which eight masons were setting facing blocks. In five and a half months of 1906, 81,000 cubic yards were built by six gangs. During that season 87,500 yards were built, including 6,500 yards of concrete blocks. Other interesting records in 1907 were: April 15,660 yards, May 16,830 yards, June 14,200 yards. The maximum ten-hour record for two cableways was: 245 two-yard buckets of concrete, 12 two-yard buckets of mortar, and some stone.

The entire plant was designed to handle a batch of concrete containing 78 cubic feet, but only 54 cubic feet at a time was permitted by the engineers, and except for this cutting down, a much larger capacity would have been shown by the cableways.

Cableways were able to pick up the stiff-leg derricks complete without dismantling and quickly move them to another part of the masonry, thus effecting a great saving in time and expense, as the derricks were generally moved during the noon hour or at night.

Landing platforms against the face of the dam received material from the cableways when the masonry became narrow as shown on preceding page.

Plate C 71

Cableways Moving Derrick

Four Lidgerwood Cableways

Plate C 332

Ashokan Reservoir

Span, each 1534; Loads, 12 Tons

The Olive Bridge Dam is the main dam of the Ashokan Reservoir for supplying water to New York City. It is located in the foothills of the Catskill Range. The reservoir is about 12½ miles long. When full it will have a water area of 12.8 square miles. Capacity of the reservoir is 128,000,000,000 gallons. The dam with its earthen wings will be about one mile long. The water passing over the waste weir will flow back into the old channel of the Esopus below the Olive Bridge Dam. The Beaver Kill dikes are divided into the west, middle and east dikes. At the junction of the middle and west dikes an aqueduct carrying the water to New York has its origin.

The contract for the construction of the main dams and dikes was awarded to MacArthur Bros. Co., and Winston & Company, September, 1907. Seven years was allowed for completion.

The construction railway is a double track road running from the junction of the Ulster & Delaware R. R. at Brown Station. Various side tracks are laid to the block yard, cement house, coal siding, compressor plant, crusher and unloading tracks under the four cableways which serve the dam. The line leads on from here to the Yale quarry branch which crosses the Esopus Creek about three-quarters of a mile from the dam and there is a quarry about two miles from the dam on a switchback. There is another line leading to the west dike. There are also two more branches, one of which supplies sand, stone and cement to the concrete mixer plant and the other delivers the earth for the embankment.

The main power plant consists of a battery of five 265 H. P. boilers which furnish steam to crushers and four air compressors. Eighty-five per cent. of the cableways and derricks are operated by compressed air; normal pressure 90 lbs. per square inch.

The masonry part of the dam is about 1000 feet long and its maximum height is 251.5 feet. It is about 190 feet thick at the base. The dam is composed of cyclopean masonry laid between walls of concrete blocks. These blocks act as forms on the faces of the dam and at the expansion joints.

The main feature of the plant for carrying on the work at the dam is the battery of four Lidgerwood Traveling Cableways, each having a span of 1534 feet and a capacity of 12 tons. The trackways along which these cableways travel are 700 feet long. On the dam the material is placed by 16 stiff leg derricks, each having a boom 60 feet long. The derricks are moved from place to place as required by the cableways. Landing platforms were used on the face of the dam when it reached such a height that the cableway towers did not serve to deliver the material directly into the dam section. From these landing platforms the material is delivered in place by the stiff leg derricks. The mixing and crusher plants are in one building about 65 feet below the crest of the dam and 500 feet from it. Beyond the mixing plant is the block yard. Eight tracks run along the bank from under the cableways to the cube mixers. Two of these tracks pass through to the block yard.

There are four 2½ cubic yard cube mixers. The rock from the quarry in skips is handled by a derrick from flat cars to a No. 9 crusher. Rejections pass through two No. 6 crushers, thence by belt conveyors and revolving screens to the bins over the mixers. The rock is fed from the bins into a belt conveyor which discharges directly into a measuring hopper. The cement comes from the cement shed on a belt conveyor. This is arranged so that the cement may be loaded onto the belt direct from the cars. Water is fed into the mixer through the axle which passes through the corners of the cube. The mixers dump directly into bottom dump buckets which are placed on small flat cars and hauled by mules directly under the cableways.

At Ashokan Dam, New York

For tbe west dike a Lidgerwood Cableway 1534-foot span was employed. The cableway was used both for excavation and handling concrete and embankment material. Tbe middle section of Beaver Kill which is a very heavy piece of dike work was bandled by a cableway of the same span as those on tbe main dam and a large amount of the excavation was handled by this cableway. Concrete was also placed by the cableway which bandled it from the mixers and delivered to tbe core walls, and part of the embankment was placed by cableway.

A Lidgerwood Cableway, 1150-foot span, is also in use on the Pressure Aqueduct and Gate Chamber wbere excavation tbrough rock was required. the rock being loaded into large skips and taken away by means of the cableway, the rock being taken to the crusber or used as cyclopean stone for the main dam. Later this cableway was used to serve concrete for constructing the Gate Chamber and Pressure Aqueducts.

Quantities include 2,055,000 cubic yards of eartb excavation, 425,000 cubic yards of rock excavation, 7,055,000 cubic yards of embankment, 1,100,000 bbls. of Portland cement, 280,000 cubic yards of concrete masonry, 602,000 cubic yards of cyclopean masonry and concrete blocks, 105,000 cubic yards of paving and riprap, 200 acres of clearing, 11,000 cubic yards of crushed stone and 950,000 feet of lumber.

The progress of the work is well up to the program of completion laid out by the engineers in awarding the contract. The photograph shows the stage of the work in the Spring of 1911.

The capacity of tbe air compressors used on the Olive Bridge Dam is 12,000 cubic feet of free air per minute.

The work is designed and supervised by the Engineering Bureau of the Board of Water Supply, Mr. J. Waldo Smith, Chief Engineer, Mr. Carleton E. Davis, Department Engineer. In charge of the work of the contractors is Mr. M. J. Look.

For bandling the concrete, buckets of $2\frac{1}{2}$ cubic yards capacity of the bottom dump type are employed. The weight of the heaviest concrete block for facing is eight tons. The steel skips for handling rock and earth measure 8 x 8 x 2 feet. Two sizes of cableway engines are used, having double 12 x 12 cylinders and double $12\frac{1}{4}$ x 15 cylinders. Main cables are $2\frac{1}{4}$ inches diameter patent locked coil steel. The towers of the four cableways are moved as required by four double cylinder 10 x 12 derrick type engines with wire ropes and blocks; two of these engines being mounted on one of the head towers and two similar engines on a tail tower. The moving ropes are so reeved through blocks from tower to tower and to anchorages at each end of the trackway tbat any tower may be moved in either direction by an operator stationed at the moving engines.

A monthly record for the four cableways on the main dam, eight bour day, was:

Cyclopean A	33,142 cubic yards
Concrete masonry	41 " "
Concrete blocks	2,117 " "
Total.......	35,300 cubic yards

Eight-bour day records for bandling concrete on the dam was 404 batches, 1010 cubic yards, in addition to which there was handled 160 yards of concrete blocks and 400 yards of large rock giving a total of about 1600 cubic yards.

The daily record for one cableway was 226 batches of $2\frac{1}{2}$ yards per trip, 565 yards, plus 10 per cent. of stone, 57 cubic yards, total 622 cubic yards.

One Lidgerwood Cableway handling eartb has taken out in eight hours 236 skips. The capacity of these skips amounts to four place yards.

Dam in South Africa

Copyright 1900 by Lidgerwood Mfg. Co., New York

Building the Foundations

Lidgerwood Cableway in South Africa

This cableway was located to command most of the work and was used to set all large stones, which were often placed 25 to 30 feet from the perpendicular line with ease, the dam being built of large rock laid in cement mortar and concrete.

This cableway was used nine hours during the day and nine at night with only one day lost time in eight months. It supplied three derricks with all the building material, and assisted in laying stone during the day.

Working at night, the cableway delivered 225 stones for working use of the derricks the following day. The average load was about three tons.

The photograph on the left shows the spoil-dumping ground near the tail tower, as well as the peculiar formation of the foundations at the centre of the dam, where the bed-rock was unexpectedly found to drop vertically about 30 feet below its ordinary level.

Dam in South America

Plate C 107

Cableway Building Dam—Tiete River, Brazil

Span, 845 Feet; Load, 5 Tons; Towers, 40-foot Head, 30-foot Tail; Engine, 10 by 12; Automatic Dump
Masonry Dam 725 Feet Long, 300-foot Curved Spillway at Centre, Developed Extensive Hydro-electric Power

Dam of East Jersey Water Co.

Plate C 10

Here was used a 725-foot span, 3-ton cableway on a concrete core earth dam, handling 300 cubic yards in 10 hours with 1½-yard buckets.

This installation proved that it paid to use a cableway simply for building the core wall.

Aziscohos Dam

Dam for Androscoggin Reservoir Co.

Span, 1200 Feet; Load, 3 to 5 Tons

This dam is located at the headwaters of the Androscoggin River in the Rangeley Lake System. The storage capacity of the dam is 8,000,000,000 cubic feet of water. The present capacity measurement of the system will be 11,000,000,000 cubic feet of water and the stored water of the new lake formed by the dam will be enough to operate the mills in the City of Lewiston for three months.

The dam is being constructed by the Androscoggin Reservoir Co., composed of the Berlin Mills Co., the International Paper Co., the Rumford Falls Power Co., and the Union Water Power Co. The design and construction was in charge of the engineering firm of Sawyer & Moulton, of Portland and Lewiston, Me.

The site of the dam is about forty miles from the nearest railway station (Colebrook, N. H.). The construction of the dam consists of piers four feet thick and twenty feet on centers with a face slab resting against their upstream sides all to be reinforced. The general dimensions are:

Total length, including core wall, 881 feet; height from ledge to top of dam, 78 feet; depth of water held by dam, 60 feet.

The sand used for the concrete was manufactured from the glacial debris on the ground. About one-half of the material was sand suitable for the concrete and the separation was accomplished by designing a plant which screened the material, mixed it with water and then separated the different size grains in a tank of flowing water. This was done by taking advantage of the fact that heavy particles settled more quickly than lighter ones. The sand grains which could be used were carried away to a storage bin. This made enough sand to provide for all the concrete that has been made up to this writing.

A quarry was opened only a few hundred feet from the dam. From this quarry crushed rock was obtained for the concrete and this was handled by a tramway which conveyed the stone to the crusher, the crushed rock being delivered to elevators which hoisted it to the top of the storage bins under which were located the concrete mixers. As soon as the concrete was mixed it was picked up by the cableway and rushed to its final resting place in the forms.

Basin Creek Dam—Butte

Plate C 110

Lidgerwood Cableway, Butte City Water Works Dam

Span, 892 Feet; Load, 6 Tons; Cable, $2\frac{1}{2}$ Inches

This dam is a masonry structure 120 feet high, with an extreme length of over 300 feet along the top, and built on a curve having a radius of 350 feet for the inner face. The dam is constructed of large stone, with spaces between thoroughly filled with concrete.

The cableway spanned dam and quarry. Stones were taken directly from the quarry and delivered to the dam without further handling. The hoisting engine was placed between the towers so that the engineman kept the load in sight at all times, and the masonry foreman set his stone by hand signals.

The cable was stretched on the chord of the inner face. Owing to the narrow space to work on, it was inconvenient to use derricks. Stones, ranging in size from $\frac{1}{2}$ to $1\frac{1}{2}$ cubic yards, were set by the cableway as easily and as accurately as they could be with a derrick.

A snubbing post and horse were used for stones remote from the line of cable, and all masonry was placed by the cableway without any derricks.

Snubbing Post

Nashua Dam

Plate C 104

Copyright, 1896, by Lidgerwood Mfg. Co., New York

The Pennichunk Water Works Dam

Lidgerwood Cableway

On the Pennichunk Water Works Dam

Nashua, N. H.

Span, 700 Feet

Load, 5 Tons

Copyright, 1896, by Lidgerwood Mfg. Co., New York
Plate C 105

Self-Filling Scoop Bucket, Dumping

Curved earth dam 300 feet long, with rough masonry core, for which rock was quarried under cableway at one end of dam.

Sand was excavated by 1-yard Automatic Scoop Bucket direct from bank at other end of dam.

Bucket dumped automatically anywhere desired along cableway into embankment fill.

Copyright, 1896, by Lidgerwood Mfg. Co., New York
Plate C 106

Bucket Filling in Gravel Bank

U. S. Lock and Dam, West Virginia

Plate C 59 Copyright, 1894, by Lidgerwood Mfg. Co., New York

Lidgerwood Cableway at Point Pleasant—Lock and Dam No. 11

Improvement of the Great Kanawha River

Span, 1505.5 Feet; Load. 4 Tons; Cable, 2½ Inches

A quarry was located on the side of river near the lock, the cableway taking stone directly to the lock and dam or to storage yard below, and also bringing material from the railroad siding on opposite bank of river.

A seam of coal underlay the quarry, and it was mined and transported by cableway to dredges, hoisting engines and pumps on the river, as well as to the boiler and electric light plant.

Lidgerwood Cableway — Harbor Improvements, Manila, P. I.

Span, 1100 Feet; Load, 8 Tons

The small cut illustrates a 1100-foot span Stationary Cableway, load 5 to 8 tons, furnished for quarrying stone in connection with the Government contract for the Manila Harbor Improvements. The cableway spanned a cove, the towers located upon the sides of opposite mountains, and the rock being handled from a quarry on either side direct to barges which transported the rock to the various jetties, breakwaters, and bulkheads at Manila.

Plate C 60 Copyright, 1904, by Lidgerwood Mfg. Co., New York

Lidgerwood Quarry Cableway

Manila, Philippine Islands

U. S. Locks in Alabama

Plate C 63

Lidgerwood Cableways for U. S. Locks in Alabama

Lock No. 3, Warrior River, Alabama

Span, 1250 Feet; Load, 6 Tons

The contractors used three Lidgerwood Long-span Cableways on excavation for, and construction of, three concrete locks and timber dams for improvement of navigation, under the U. S. Engineer Corps, including Lock No. 1, Tombigbee River, cableway span 1400 feet, and Locks Nos. 2 and 3, Warrior River, spans 1200 and 1250 feet.

Cement houses on either side of cable, stored cement above high water, unloaded by cableway from river.

Cableways pay for themselves as insurance against flood losses.

Plate C 64

Lidgerwood Traveling Cableway—Colbert Shoals

Used by U. S. Corps of Engineers at Riverton, Ala., for Lock-Building

Span, 370 Feet; Head Tower, 60 Feet High; Tail Tower, 35 Feet High; Load, 5 Tons; Engine, 9 by 10 Cylinders

U. S. Lock and Dam, Kentucky River

Plate C 55

Lidgerwood Cableway, Lock and Dam No. 10, Kentucky River

Span, 465 Feet; Load, 4 Tons

The illustration shows one of our lighter forms of stationary cableways used for the completion of a concrete dam across the Kentucky River. A 1¾-inch diameter main cable was supported on "A" frame towers, and loads up to 4 tons were handled by a 9 by 10-inch double cylinder tandem drum cableway engine.

This cableway was installed for the completion of the Government work at lock No. 10. The lock itself and a small portion of the dam having been built during a previous season.

It is quite customary for work of this character under the United States Engineer Corps to be done in a series of contracts. First, the lock, then a portion of the dam, and a final contract covering the completion of the dam. This method is employed, as the appropriation for the entire work is frequently not available in time for any one contract. An interesting feature of this system of building these Government locks is, that even for a contract covering only part of the work, cableways have been very frequently used because, while the total yardage handled by the cableway may be comparatively small, the great adaptability of such a device, its facility for handling forms and any machinery or material within reach is a strong argument in its favor and one which contractors and others should not overlook.

The cableway illustrated above cost comparatively little more than a long boom derrick, and, having very much greater usefulness, it proved a most economical plant, completing the contract in a short season.

U. S. Lock and Dam, Ohio River

Plate [illegible]

Lidgerwood Radial Cableway, Lock and Dam No. 4, Ohio River

Span 1485 Feet; Load 5 Tons; Cable 2¼ inch Diameter

This long span cableway was arranged with a 125 foot stationary head tower, and 103 foot 6 inch traveling tail tower, designed to allow a small amount of radial movement in order to reach the area covered by the construction of the dam. The cableway engine had double 10 by 12 cylinders and drums 53 inch diameter. At the head end there was very little space available for tower and anchorage, and for that reason a tower of special design was employed to allow the main anchorage to be located inside the main line of the Railroad and much closer to the tower than permissible with the usual form of tower.

A sufficient clearance above low water to clear navigation was provided in accordance with the requirements of the United States War Department. This cableway was installed to construct the dam, the lock having been previously built.

The Ohio River is subject to frequent floods, and a cableway is of great value in addition to its regular work, on account of its being enabled to quickly remove to the bank of the river the auxiliary plant, as well as surplus materials, which would otherwise be carried away during the floods.

Indiana Chute Dam, Kentucky

Plate C 444

Improvement of Falls of Ohio River at Louisville, Ky.

Chanoine Dam, Section No. 10 – Across Indiana Chute

Span, 1370 Feet Load, $2\frac{1}{2}$ Tons

The illustration shows a Lidgerwood Cableway with stationary towers furnished the U. S. Engineers' Office, Louisville, Ky., Major Burgess.

This work was done in 1908. After blasting the disrupted rock was removed and placed behind the concrete dam by means of the cableway which was erected for use in constructing sections Nos. 10 and 11. The wickets and hurters for this dam were loaded on barges at and along the canal bank and towed along the side of the bank where they were placed into position by means of the cableway.

The span of this cableway was 1370 feet. Load handled $2\frac{1}{2}$ tons. The towers were 85 feet head and 100 feet tail. Main cable $1\frac{3}{4}$ inches plough steel. Hoisting engine of the Lidgerwood Cableway type with double tandem friction drums and cylinders 10 x 12. Drums 53 inches diameter.

A cableway standing on banks above high water is independent of floods. This is a factor of great value on such rivers as the Ohio.

U. S. Lock and Dam No. 11, Kentucky River

Plate C 56

Two Lidgerwood Radial Traveling Cableways

Spans, 680 Feet; Load, 1¼ Cubic Yard, Orange-Peel Bucket

Two 4-ton capacity radial cableways operated about one common fixed steel pivot tower. Each cableway handled a 1¼-yard Orange-Peel bucket for excavating, also concrete tubs, placing concrete for dam and lock walls.

Engine on each head tower, 10 by 12-inch double cylinders and three 41-inch diameter tandem friction drums, equipped with propelling winch for moving the tower so that loads were hoisted or delivered at any point within the arc represented by an angle of about 82 degrees; towers moving independently, thus covering the entire work.

The head towers were sufficiently high to clear the Government lock house, back of which they traveled. Concrete was made on the side of the river opposite the lock houses, rock being obtained nearby. The crusher located near pivot tower produced all the sand of different grades as well as the rock for the concrete.

Plate C 57

Rebuilding Government Breakwater

Plate C 65 Copyright, 1900, by Lidgerwood Mfg Co., New York

Lidgerwood Cableway—Traveling Head Tower

Rebuilding Cleveland, Ohio, Breakwater

Span, 500 Feet; Load, 2 Tons; Handling Concrete, Head Tower Traveling

The traveling head tower was very narrow, to permit passage along the breakwater of narrow-gauge supply cars. It was especially designed to resist wind pressure, and proved exceedingly stable in several hurricane winds. The "A" frame tail tower was moved along as work progressed.

This cableway was especially interesting in that it traveled in the direction of tbe cable instead of at right angles to it, and was anchored to the breakwater when in use.

The work was carried on in sections under the cable, the old stone filling being removed by cableway to crusher and converted into concrete. The old top courses of timber were removed to five feet below the water line, new timbers added, and a row of concrete blocks, each 20 tons in weight, set along each edge of the breakwater, and another row of 15-ton blocks along the centre. This was done by a derrick boat. Then the concrete filling was completed by the cableway.

Plate C 66 Copyright, 1900, by Lidgerwood Mfg Co., New York

Dumping a Load of Concrete

Seven Cableways on Dam

Stationary Lidgerwood Cableways Constructing Dam

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Washington Water Power Company

Plate C 335

Three Lidgerwood Cableways Constructing Dam for the Washington Water Power Co.

Span, 1522 Feet; Loads, 6 to 10 Tons

These cableways are located down the Spokane River, about thirty miles from the City of Spokane, where the Washington Water Power Co. are constructing a dam 200 feet high. The dam is located in a very narrow gorge, the head tower side of the cableway being about 400 feet above the river. The tail towers are located about 150 feet lower than the head towers. The cableways handle the concrete used in the construction of the dam. These three cableways, with five derricks, will cover every portion of the excavation and concrete work. The dam is one of the largest spillway dams in the United States. The controller works will be of the German roller patent, among the first to be used in this country. The concrete mixers, of which there are two, of two cubic yards capacity each, will be placed underneath the cableways on a ledge blasted out from the cliff. The mixers are of the Hains Gravity type.

To unwater the river so that the foundation of the plant can be put in a tunnel was driven through solid rock; section of tunnel 27 x 30 feet. This comes out below the power house. The muck from the tunnel on the down-stream side is handled by the cableways. The cableways are worked double shift and handle on an average about 1300 place yards of rock per day.

The patent aerial dumping device is used with each cableway.

There will be about 80,000 cubic yards of excavation to be handled by these machines and from 150,000 to 200,000 cubic yards of concrete to be placed. The smaller machinery, piping, etc., will also be handled by the cableways, there being a branch from the main line of the Company's railroad to points underneath the cableway head towers.

Barker Dam

Two Lidgerwood Cableways on Barker Dam

Central Colorado Power Co.

[illegible] the branches of the Boulder River. The principal features of this development, called the Boulder Hydro-electric Plant, are: Storage reservoir of 520,000,000 cubic feet capacity, the reservoir being formed by a concrete dam 172 feet high. From this dam a 36-inch concrete pipe line on a gravity grade 12 miles long leads to a terminal reservoir of large capacity for peak and emergency load use. The pressure pipe from this terminal reservoir to the power plant is the heaviest of its kind ever constructed, being 9800 feet long, 44 inches diameter and 1½ inches thick. The plant operates under 1830 feet static head. The power house has two impulse wheels of 10,500 H. P. each direct connected to 5000 K. W. generators. A secondary reservoir below the power house stores the tail water and allows the Company to complete the filling of its primary storage reservoir in the early summer, at the same time protecting the irrigation rights on the stream.

The dam for the Barker Reservoir is of cyclopean concrete of gravity section 172 feet high at centre with 16 feet width at top and 125 feet width at the bottom.

Feather River Dam

Plate C 346

Two Electrically-Operated Cableways of the Great Western Power Co.

Spans, 1000 Feet; Loads, 15 Tons

The plants illustrated above are 15 tons capacity Lidgerwood Stationary Cableways. These were installed for use in constructing the large concrete dam on the Feather River at Intake. The span of each cableway is approximately 1000 feet. The cableway hoists are electrically operated, each being equipped with a 300-H. P. alternating current motor wound for 3-phase, 60-cycle, 440 volts. The magnetic control is used with complete equipment of contactor panels, switches, overload relays, etc. The cableways have been used day and night without interruption.

Plate C 337

35-Ton
Lidgerwood Cableway

Great Western Power Co. Transporting Machinery and Material Across River.

Blewett Falls Dam

Plate C 67

Two Long-Span Lidgerwood Cableways

Spans, 1840 Feet; Load, 5 Tons; Towers, 100 Feet

Two unusually long-span cableways were installed for the construction of a cyclopean concrete dam across the Yadkin River in North Carolina, for a hydro-electric development of about 30,000 H. P., length of dam between abutments 1469 feet, the spillway portion of which is 1319 feet long. Short earth dams, with concrete cores extending 10 feet above the crest of the main dam, extend the structure at each end to a total length of 2270 feet. The dam contains about 100,000 yards of masonry, and has an average height of about 50 feet.

The up-stream cable is placed seven feet below the line of up-stream or vertical face, the other cable being 15 feet further down-stream, thus enabling the cableways to command the full width of the work. In order to place these cables 15 feet apart, the towers of one cableway were set somewhat in advance of the corresponding towers of the other, as the bases of the towers were, in each case, more than 30 feet square.

One of our traveling cableways of 600-foot span was used for constructing the power-house and head works containing about 40,000 yards of concrete.

Plate C 68

Lidgerwood Cableway Building Coffer-dam

Span, 1200 Feet; Load, 3 Tons

This cableway was used to build the up-stream coffer-dam in connection with a hydro-electric development of over 135,000 H. P., involving the construction of a concrete dam containing about 330,000 yards of concrete across the Susquehanna River at McCall Ferry, Pennsylvania.

Roosevelt Dam

Plate C 86

Three Cableways—Roosevelt Dam—U. S. Reclamation Service

Spans, 1146, 1106 and 810 Feet; Load, 8 Tons Average; 15 Tons Maximum, Electrically Operated

One of the largest and most interesting projects of the U. S. Reclamation Service was the construction of the Roosevelt Dam in the canyon of the Salt River below the mouth of Tonto Creek. Two long-span electrically-operated Lidgerwood Cableways, each adapted to handle maximum loads of 15 tons, spanned the canyon, handling rock direct from two spillways cut out of solid rock around the ends of the dam, and delivered same directly to the masonry-building derricks. Most of the rock required came from these spillway excavations, although a third cableway of shorter span was installed up and down-stream on the north side of the river to deliver additional rock from a quarry upstream. The masonry-laying derricks are equipped with special Lidgerwood Electric Hoists.

The illustrations are from early photographs taken during high water.

The entire contractor's plant was operated by 25-cycle AC, 2200-volt current, furnished by the Government, which was also used to operate the Government cement mill. The contractor, however, converted to 500-volt, direct current, before using to operate the hoists.

Plate C 87

Head Towers

Roosevelt Dam

Plate C 339

Roosevelt Dam Nearing Completion

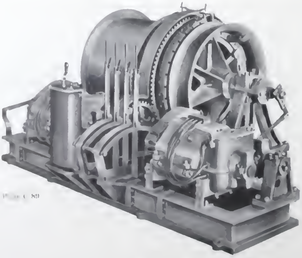


Plate C 89

Double Drum Electric Cableway Hoist

Drums, 51-inch Diameter

2 GE 57 Direct-Current, 500-Volt Motors — Series Parallel Controller

The dam will contain about 340,000 cubic yards of broken range cyclopean rubble, large stone being laid in Portland cement mortar, the voids filled with concrete, the cement being manufactured by the Government near the dam. The dam is curved up stream, the radius of the arch 400 feet, length at mean low water along the arch axis 235 feet, length at crest 1080 feet, maximum height above foundation 284 feet, height above mean low water being 240 feet. The spillways around the dam, each 200 feet long with crest elevation 220 feet above mean low water, are spanned by reinforced concrete bridges carrying a 16-foot roadway which will cross the top of the dam; the neat thickness at top of dam is 16 feet, and width over cornices 20 feet. The full storage capacity of the reservoir will be 1,284,000 acre feet, covering a surface area of 10,320 acres.

The Government hydro-electric development includes a small diversion dam on the Salt River, a power canal about 20 miles long discharging through a tunnel around the dam, which will ultimately connect with a large power house to be built below the dam. The water stored by this reservoir will be used to maintain a uniform flow in the Salt River for irrigation purposes, and the power developed will be used to pump from deep wells for further irrigation in the country around Phoenix.

Shoshone Dam

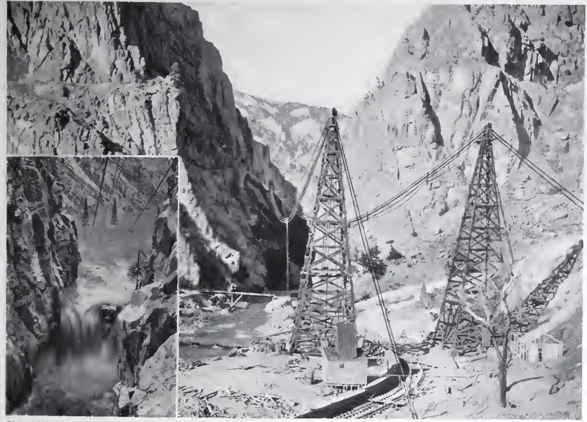


Plate C 340
High Water During Construction

Plate C 90

Two Cableways—Shoshone Dam—United States Reclamation Service

Spans, 1275 and 1250 Feet; Load, 6 to 10 Tons; Automatic Dump

The highest masonry dam in the world, located eight miles west of Cody, Wyoming, in the canyon of the Shoshone River, will contain about 69,000 cubic yards of monolithic masonry, using 1–2½–5 Portland cement concrete, with at least 25 per cent. of the mass made up of blocks of granite, 25 to 200 pounds in weight, rammed and bedded to secure uniform distribution. The dam will be curved upstream, length of crest along arch axis about 180 feet, height 305 feet, with foundation 60 feet below river bed, maximum width at base 108 feet, batter, up-stream face 15 per cent., down-stream face 25 per cent.

The two Lidgerwood Cableways were located at right angles to the axis of the dam, in order to have control of the deep excavation 60 feet below the river bed, containing about 32,000 cubic yards, largely boulders, some of enormous size, as well as over 10,000 cubic yards of solid rock in the sidewalls of the canyon, all of which was hoisted by the cableways and dumped automatically in the clear space where the reservoir widens out above the canyon. Most of this excavation being rock, it will be returned from the spoil area and built into the dam along with the concrete, which the cableways are also located to handle to the best advantage.

The concrete will be mixed and delivered to the cableways at a point several hundred feet upstream from the dam, the crushing and mixing plant being located on the slope of the hill to the left, about where the derrick is shown. The cableways have 125-foot head towers, 90 feet apart, so as to give a wide spoil area for the excavation, but with a single 25-foot duplex tail tower, having the cables 5-foot centres, designed so that the cables are about 35 feet apart over the dam itself, thus reaching all parts of the structure with very little side swinging.

The dam will be located where the black shadow in the canyon shows in the centre of the above photograph, and as the sidewalls are almost vertical, it will form an immense narrow wedge in a most ideal location for a high dam.

Pathfinder Dam

Two Cableways—Pathfinder Dam—U. S. Reclamation Service

Spans, 344 Feet; Loads, 6 Tons Average; 10 Tons Maximum

A high masonry dam was built to conserve the waters of the North Platte River for irrigation purposes, in the canyon through which that river flows, about fifty miles southwest of Casper, Wyoming.

The dam is a masonry structure, its centre line curved up-stream to a radius of 150 feet through an angle of 86 degrees and 30 minutes between the centres of the circular end abutments. The maximum height is 210 feet from the foundation to the level of the roadway, 10 feet wide, which crosses the top of the dam. The width of the dam at the top is 14 feet, with cornices at each side carried 4 feet above the roadway level. The up-stream face has a batter of 15 per cent., the down-stream face 25 per cent., with a maximum bottom width of about 94 feet. The full supply level of the water surface is about 10 feet below the roadway, with a spillway at one side about 575 feet long. The dam was built of broken range cyclopean rubble masonry, with stones up to 10 tons laid to break joints in heavy beds of mortar, the side joints being filled with Portland cement concrete rammed in place.

At each end of the dam, reinforced concrete bridges carry the roadway across the spillway channels. The dam required about 53,000 yards of masonry, and the bridges, spillway guide walls and gate towers, about 1000 yards of concrete.

The two cableways handle all the material for the construction of the dam. The towers are about 50 feet high, main cables 2-inch diameter patent locked, engines 10 by 12-inch double cylinders with double 33-inch diameter tandem drums. All parts of the cableways were designed as light as possible on account of the remoteness of the work from railroad facilities.

Medina Irrigation Co. Dam

Cableway Head Towers and Concrete Mixing Plant

This dam is being constructed on the Medina River, about thirty-five miles west of San Antonio, Texas, for the purpose of impounding the waters of this torrential stream for the irrigation of a tract of approximately 60,000 acres near San Antonio. The dam is of the gravity type and will have a seepage and inspection tunnel throughout the length of the main dam near the up-stream face. Height of dam 166 feet, containing about 280,000 cubic yards of cyclopean concrete. Width of dam between the walls of the canyon approximately 550 feet; length of the crest about 1500 feet. This dam will form a lake 18 miles long, containing 300,000 acre feet of water.

Two Lidgerwood Stationary Cableways of six tons average ten tons maximum capacity, one of 1200-foot span with 100-foot towers; the other 1180-foot span with 70-foot towers, are used to deposit the concrete and stone. Large stone is delivered to the cableway by 36-inch gauge cars brought from the quarry a short distance up-stream from the dam, above the spillway and

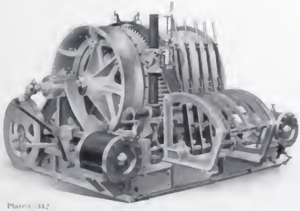


Plate C 412

The Steam Hoist

Cylinders, Double 12 x 12; Drums 53 Inches Diameter

Medina Irrigation Co. Dam

Plate C 341

General View at Main Dam Site

Spans, 1200 and 1180 Feet; Loads, 6 to 10 Tons

partly in it. Concrete is delivered from the mixers into two-yard bottom dump buckets on flat cars and hauled from the mixers to the cableways, a distance of about 100 feet.

At the west end of the dam is located the construction plant with central boiler house, electric light plant, etc. The cement shed has a capacity of 12,000 barrels. The crushing plant consists of two 7½D Gates crushers and two 36-inch crushers. From the crushers the stone is carried by bucket elevators to the high material bins, capacity 1000 cubic yards crushed stone, 600 cubic yards sand and dust. The material as it comes up on the elevator is delivered to revolving screens which separate the dust and deliver it to one bin, the sand or fine gritty product to another bin and the stone to the main compartment. Part of the stone is deflected back into a chute which carries it down to the 36-inch crushers where it is further reduced and returned through the same screening process. Another portion of the finer screenings is delivered to two 18-inch disc crushers and two Williams pulverizers which are located at the top of the bin. Under the bin there are a battery of five mixers, capacity of each one cubic yard per batch and thirty batches per hour. Stone, sand and dust are delivered direct into the mixer hoppers from chutes by the bottom of the bins. Cement is delivered by belt conveyor either from the shed or direct from the cars to the mixer platform.

There will also be a curved diversion dam 48 feet high with a maximum width of base of 46 feet, length of crest 450 feet. This dam which is located four miles below the main dam will form a reservoir covering an area of 200 acres. The construction plant for this dam will be somewhat similar to that on the main dam on a much smaller scale. One Lidgerwood Stationary Cableway, three to five-ton capacity, span about 650 feet, will be used on this dam.

The work is being planned and supervised by the Pearson Engineering Corporation, Ltd.

High-Speed Cableways

These cableways are *High-Speed Cableways* equipped with our Panama type of Carriage and Shock-Absorbing Fall Rope Carrier (see pages 7, 8 and 9), and are operated by our latest type of High-Speed Balanced Hoisting Engine.

La Boquilla Dam

Mexican Northern Power Co.

Four Traveling Cableways. Spans, 1230 to 1393 feet—Loads, 7 to 10 tons

La Boquilla Dam, across the Rio Conchos, in the State of Chihuahua, Mexico, is one of the large masonry dams of the world. Its height is 261 feet from the bottom of the heel trench to the top of parapet, and it retains 228 feet depth of water. Its top width will be 19 feet and the bottom width of the maximum section will be 200 feet at low-water elevation. The dam is curved convex upstream to a radius of 866 feet, and its top length is 840 feet. The maximum section extends lengthwise across the stream for about 361 feet. The dam will contain about 390,000 cubic yards of masonry. The reservoir formed by this dam will have a capacity of about seven hundred and forty billion gallons and will flood an area of 58 square miles.

The foundations, to a level above ordinary high water, are built of concrete made from Portland cement, a very well graded river sand and graded gravel or graded crushed limestone of a maximum diameter of four inches, all mixed in Smith mixers.

The bulk of the dam is of cyclopean masonry.

Four Lidgerwood Traveling Cableways, spans 1230 to 1393 feet, are employed on this work.

The cableways are each designed for average loads of seven tons and maximum loads of ten tons. They are each arranged with the patent aerial dumping device.

The cableways are used for placing concrete during the day and furnishing stone to the derricks at night. The derricks place stone at night and concrete during the day. All power used on the work is direct current, 550 volts.

The dam is being constructed by the Mexican Northern Power Co. Mr. Wm. B. Fuller is chief engineer.

Messrs. John R. Freeman, Frederick P. Stearns and Isham Randolph have been connected with the work as consulting engineers, reporting on the general features of the power development and construction work.

The site of the dam is at La Boquilla, not far from Santa Rosalia, Chihuahua, Mexico.

The cut, made from a photograph taken in the Summer of 1912, gives a good general view of the work.

Lahontan Dam

Truckee-Carson Project—U. S. Reclamation Service

Traveling Cableway. Span, 1600 feet—Load, 10 tons

In the construction of Lahontan Dam for a storage reservoir in Carson River, Nevada, the water power available in the main canal is to be utilized for driving practically all construction motors.

The development of 1000 kilowatts, in duplicate 500 kilowatt units, has been completed, and this power plant is now in regular operation 24 hours daily for driving the construction plant and for lighting the camp. The current is 3-phase, 60 cycles, 2200 volts.

The construction plant has a number of large units; among others a 1600-foot span Lidgerwood 10-ton Traveling Cableway, driven by a 300-H. P. motor, a 30-inch by 900-foot belt conveyor, other small conveyors independently motor-driven, a drag line excavator, and a number of derricks, pumps, a concrete mixer, hoisting engines, a machine shop, an air compressor, and smaller units of equipment all driven by electric motors. Where convenient the motors, including the cableway motors, are driven by the current as generated at the power plant a few hundred feet distant, but in some cases where the motors are more exposed the current has been transformed to 440 volts for driving the separate motors.

Transporting a 16-Ton Locomotive

The work to be done in the construction of the dam comprises about 1,000,000 yards of excavation and embankment and about 75,000 cubic yards of concrete, both plain and reinforced. The dam will be of the earth embankment type with a concrete spillway 250 feet in length at each end. The extreme length of

Lahontan Dam—*Continued*

the dam will be about 1200 feet, the thickness of the base about 600 feet, and the maximum height 124 feet above river bed, plus 50 feet penetration of the concrete cut-off wall below the bed of the river.

The general scheme of the operation is to place the widely distributed concrete by means of the traveling cableway, materials being delivered to the concrete mixer by the belt conveyor.

Landing 3-Yard Bucket of Concrete on Distributing Tower

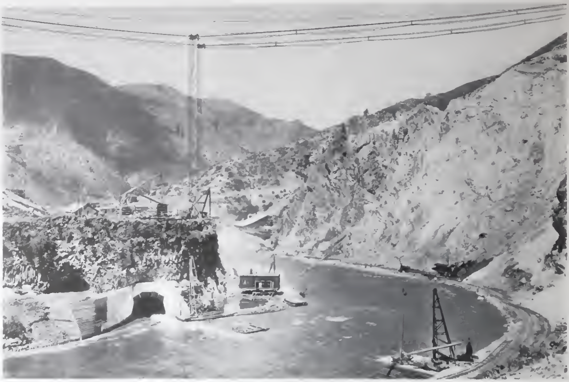
Shifting Distributing Tower with the Cableway

The cableway (locally known as the "sky hook") is used to land the three-yard buckets of concrete on the movable tower. The concrete is then distributed with a spout into the comparatively thin walls and otherwise widely spread concrete. The cableway necessarily crosses the directions of the walls. Therefore, with this plan the concrete is deposited where required without a constant moving of the cableway. Much time is saved by this method, as the bucket goes to the same spot for hours at a time, is quickly dumped and returned, while the interval between buckets is occupied in pouring the concrete exactly where it is wanted by a movable spout, with the minimum of shoveling and placing, a 40 to 50-foot section of wall being filled from one setting of the distributing tower. The tower is then shifted by the "sky hook" to its next position.

Cableway Taking Hopper over to Flume for Handling Sand from Bed of River on One of U. S. Reclamation Projects

The entire work is being carried on through the direct employment of labor and purchase of materials by the United States. Mr. F. H. Newell is Director and Mr. A. P. Davis, Chief Engineer. The field organization consists of Mr. E. G. Hopson, Supervising Engineer; Mr. D. W. Cole, Project Engineer; and Mr. L. G. Maney, Superintendent of Construction.

Arrow Rock Dam



Boise Project—U. S. Reclamation Service

Two Cableways. Spans, 1395 and 1438 feet

Cableway Handling "Andresen Evans" Self-filling Bucket

The Arrow Rock Dam, about 351 feet in height, which will store water in the Arrow Rock Reservoir for the Boise Project of the United States Reclamation Service, is in the cañon of the Boise River, about 20 miles above the city of Boise. The cañon at this point is narrow, with high, steep, bare granite cliffs on the north side, and on the south side a less precipitous slope.

On account of the high cost of coal, the expense and inconvenience for extensive storage and the uncertainty of obtaining the necessary supply during all seasons for the operation of the construction plant, electric power is used as far as practicable. For this power a 1500-kilowatt plant was constructed at the Boise Diversion Dam, about 15 miles down the river.

Two Lidgerwood Electrically Operated Stationary Cableways, employing alternating current of 3-phase, 60 cycles, 2200 volts, are used. Spans are 1395 and 1438 feet. These cableways are designed for operating either skips or self-filling buckets, and the small view shows the latter in use on one of the cableways. When skips are used on the excavation they are filled by hand by a drag line scraper or by derrick with an orange-peel bucket. The large general view shows the drag line excavator in working position. During the month of October, 1912, 29,700 cubic yards (place measurement) were handled by these cableways—average load per trip, 2.67 cubic yards. The average height of hoist was fully 300 feet; average travel, 440 feet.

This work is being carried on under the general direction of F. E Weymouth, Supervising Engineer, Idaho Division. Mr. Chas. H. Paul is Construction Engineer; Mr. James Munn, Superintendent of Construction.

Engle Dam

Rio Grande Project—U. S. Reclamation Service

Three Cableways. Spans, 1416 and 1436 feet—Loads, 10 to 15 tons

The Engle Dam, now under construction on the Rio Grande at Elephant Butte, N. M., will form a reservoir more than 40 miles long, with a storage capacity of 2,760,000 acre-feet. This will be the largest artificial body of water in the world, and will provide for the irrigation of 180,000 acres of land in New Mexico, Texas and Mexico, extending from the dam site, 125 miles from El Paso, down the Rio Grande Valley, a distance of 160 miles. The dam is located between sandstone bluffs, and is to be a rubble concrete structure of gravity section, with a maximum height above foundation of 264 feet and a crest length of 1200 feet. At the west end of the dam a spillway is provided, 300 feet long, excavated from the solid rock. During construction the river will be diverted through a concrete-lined flume forty feet wide and fourteen feet deep.

Three Lidgerwood Electrically Operated Cableways, spans 1416 to 1436 feet are employed on this work; each cableway being designed for loads of 10 to 15 tons and each arranged for operating either a self-filling bucket, tubs or skips. Each cableway hoist motor is 300 H. P., employing alternating current, 3-phase, 60 cycles, 2200 volts; the electrical equipment being the same as that used on the Arrow Rock Dam.

An interesting feature connected with the work, one that has attracted considerable attention, was the transportation of a twenty-ton locomotive across the river by the use of two cableways operating in unison. Mr. L. C. Hill is Supervising Engineer; Mr. H. J. Gault, Engineer; and Mr. E. W. Baldwin, Construction Engineer.

Two Cableways Taking 20-Ton Locomotive Across River

Guyabal Dam

Porto Rico Irrigation Service—Porto Rico Government

Two Stationary Cableways. Spans, 1100 and 1168 feet

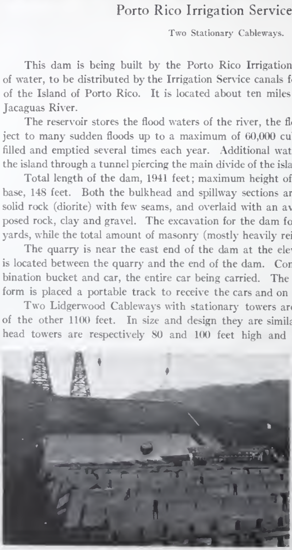
This dam is being built by the Porto Rico Irrigation Service for the storage of approximately 10,000 acre-feet of water, to be distributed by the Irrigation Service canals for the irrigation of sugar-cane lands along the south coast of the Island of Porto Rico. It is located about ten miles northeast of the City of Ponce, across the channel of the Jacaguas River.

The reservoir stores the flood waters of the river, the flow of which is usually very small; but as the river is subject to many sudden floods up to a maximum of 60,000 cubic feet per second, the reservoir will be wholly or partly filled and emptied several times each year. Additional water for this reservoir will be taken from the north slope of the island through a tunnel piercing the main divide of the island. This tunnel, 2770 feet long, has just been completed.

Total length of the dam, 1941 feet; maximum height of the dam, 115 feet; and width up and down stream at the base, 148 feet. Both the bulkhead and spillway sections are of the Ambursen type. The foundation for the dam is solid rock (diorite) with few seams, and overlaid with an average (except in river channel) of 18 to 20 feet of decomposed rock, clay and gravel. The excavation for the dam foundation and for the earth section will total 81,000 cubic yards, while the total amount of masonry (mostly heavily reinforced) will be 39,000 cubic yards.

The quarry is near the east end of the dam at the elevation of the dam crest. The crushing and mixing plant is located between the quarry and the end of the dam. Concrete is transported from the plant to the dam in a combination bucket and car, the entire car being carried. The car itself is light, for handling. On top of each buttress form is placed a portable track to receive the cars and on which to distribute the concrete.

Two Lidgerwood Cableways with stationary towers are employed, the span of one being 1168 feet and that of the other 1100 feet. In size and design they are similar to the cableways described on pages 47 and 48. The head towers are respectively 80 and 100 feet high and the tail towers 110 and 125 feet high. The cableway hoists are of the latest type with double 12 x 12-inch cylinders and 53-inch diameter drums. Size and type of hoist as illustrated on page 47. The cableways move and set all forms and portable track in addition to handling the concrete.



The small view shows two cableways in use moving one of the large forms, 72 feet long. Both cableways are high speed, the carriage being of the pivoted equalizing type with self-adjusting horn, and the carriers of the shock absorbing type illustrated on pages 7 to 9.

The dam is being built by the administration forces under the direction of Mr. L. V. Branch, Division Engineer. Mr. J. W. Beardsley, member A. S. C. E., is Chief Engineer of the Porto Rico Irrigation Service.